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DIRECTORATE OF
INTELLIGENCE

Intelligence Memorandum

Recent Trends In Soviet Satellite Communications

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CENTRAL INTELLIGENCE AGENCY
Directorate of Intelligence
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INTELLIGENCE MEMORANDUM

Recent Trends In Soviet Satellite Communications

Introduction

Technological change within the Soviet communications satellite (comsat) program has been much slower than that achieved by the Western-based Intelsat consortium. Now in its sixth year, the Soviet comsat system is still dependent on essentially "first-generation" technology for operational space and ground segment hardware. New subsystems -- both satellites and ground stations -- are currently under development, however, which should provide the USSR with a substantially more advanced comsat system within the next year or two.

This memorandum assesses recent developments in Soviet satellite communications and examines trends in system planning. Estimates of the aggregate cost of the Soviet comsat program and its major components are also included. These are the first such estimates within the US Intelligence Community.

Satellite Developments

Molniya-1

1. With the launch of two more Molniya satellites in February and June 1970, the USSR has now successfully orbited 14 comsats of the Molniya-1 type since April 1965. The highly elliptical orbit

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of the Molniyas causes them to pass repeatedly through the Van Allen radiation belts. The degenerative effects of this radiation and poor quality control of the satellites' components have probably been the primary causes of the relatively short useful lifetimes exhibited by the satellites thus far. Of the 14 Molniyas orbited, probably only the four or five most recently launched are still active. These satellites are capable of relaying 60 two-way telephone conversations, but thus far the system's primary emphasis has been on the relay of television from Moscow to a network of ground stations dispersed throughout the USSR.

2. A primary consideration in the Soviet choice of a highly elliptical orbit (rather than an equatorial synchronous orbit) for the Molniya system was that it provides excellent coverage of the northern latitudes. This choice has resulted, however, in a number of disadvantages. In addition to the short operating lifetime of the satellites, the elliptical system requires a minimum of two satellites in orbit at the same time to provide continuous 24-hour coverage of the USSR. In order to optimize system coverage and reliability, the USSR uses three or four satellites operating in tandem. The combination of short operating lifetimes and large numbers of satellites required for reliable operation greatly increases the cost to the USSR of maintaining the Molniya-1 system.

Molniya-2 and Statsionar

3. The USSR is planning to launch two new types of communications satellites -- a second-generation Molniya to be known as Molniya-2 and a geo-stationary satellite called Statsionar. Although their orbits will differ widely, both satellites will have similar technical characteristics. Molniya-2 will be positioned in the same highly elliptical orbit as the Molniya-1 series, while Statsionar is scheduled to be placed in synchronous equatorial orbit over the Indian Ocean.

4. Information filed by the USSR with the International Frequency Registration Board (IFRB) of the International Telecommunication Union (ITU) indicates that these second-generation satellites will operate in the internationally recommended frequency range of 4-6 gigahertz (GHz) rather than

the 800-1,000 megahertz (MHz) range used at present for Molniya-1 operations. The additional bandwidth provided by the frequency shift will greatly increase the potential channel capacity of the new satellites and will allow the simultaneous relay of both television and multichannel voice transmissions, which is not possible with the Molniya-1 satellites. The additional bandwidth also fits well with Soviet plans to develop an operational multiple-access capability (whereby many ground stations can work with a satellite at the same time), a highly desirable feature for a satellite communications system if it is to operate in conjunction with land-based telecommunications systems.

5. Successful development and deployment of the Statsionar satellites would serve at least two important objectives. First, Statsionar should have a much longer useful lifetime than the present Molniya series, an advantage that satellites in synchronous orbits have exhibited over those in highly elliptical orbits. This extended lifetime would reduce the long-run costs to the USSR of operating a satellite communications system. Secondly, the USSR almost certainly does not want synchronous satellite technology to remain the exclusive province of the West. In order for the USSR and most of the Third World countries to be mutually "visible" via satellite, an equatorial synchronous orbit is necessary.

6. Soviet authorities have filed with the IFRB a probable launch date of December 1970 for Statsionar. However, owing to serious problems encountered with the only Soviet booster (the SL-12) capable of placing Statsionar into equatorial synchronous orbit, there is considerable doubt now that this target date can be met. Placing the Molniya-2 into elliptical orbit should not confront the USSR with any serious problems, but Moscow has supplied no information on the initial launch date for this satellite.

Ground Station Developments

Domestic

7. The USSR has developed the world's first and only domestic satellite television distribution system. The impetus for development of this system

derives from the importance attached by the Soviet leadership to the expansion of television as a centrally controlled propaganda medium.* Coincident with the fiftieth anniversary of the Bolshevik Revolution in 1967, the USSR put into operation a network of special-purpose satellite ground stations (known as "Orbita" stations). Currently, these stations are capable only of receiving one channel of television; they can neither transmit television nor handle telephone and telegraph traffic. In addition to the Orbita stations, there are ground stations at Moscow and Vladivostok (known as Molniya stations) which can both transmit and receive and are used for relaying telephone and telegraph traffic as well as television between the two cities.

8. The Orbita network in the USSR has grown from 20 stations at the end of 1967 to 29 by mid-1970, with 8 more currently under construction and two more in the active planning stage (see Table 1). A senior official of the Soviet Ministry of Communications has stated that the network will continue to expand at the rate of 6 to 8 new stations per year. The USSR has not provided any forecast of the ultimate size of the Orbita network, but a total of at least 50 stations seems more than likely.

9. Many of the Orbita stations are located east of the Urals in sparsely populated areas where there are few land-based communications lines capable of carrying television signals. In the selection of these areas for construction of Orbita stations the importance of television for propaganda may well have been subordinate to the government's desire to help make life in remote areas less unattractive.

10. The physical expansion of the Orbita network has been accompanied by the steady growth of Orbita programming. In 1968 the Orbita network relayed about 40 hours per week of live Moscow telecasts. This figure rose to 50 hours per week in 1969 and is increasing again in 1970 by a further 25%. In addition, a number of the Orbita stations are being technically modified so that they can receive television programs from Moscow in color. At four of

25X1

Table 1

Soviet Ground Stations a/

Molniya Stations -- Operational

Moscow (Molniya-2 and Statsionar)
Vladivostok

Orbita Stations -- Operational

Abakan
Alma Ata
Archangelsk (Molniya-2)
Ashkhabad (Statsionar)
Blagoveshchensk
Bratsk
Chita (Statsionar)
Dzhezkazgan
Frunze (Statsionar)
Guryev
Irkutsk (Statsionar)
Kemerovo (Statsionar)
Khabarovsk (Statsionar)
Komsomolsk (Molniya-2 and Statsionar)
Krasnoyarsk
Kyzyl
Magadan (Molniya-2)

Orbita Stations -- Operational (Continued)

Murmansk (Molniya-2)
Norilsk
Novosibirsk (Molniya-2 and Statsionar)
Okha
Petropavlovsk (Molniya-2)
Surgut (Molniya-2)
Syktyvkar (Molniya-2)
Ulan Ude (Statsionar)
Uray
Vorkuta
Yakutsk (Statsionar)
Yuzhno-Sakhalinsk (Statsionar)

Table 1

Soviet Ground Stations a/
(Continued)

Orbita Stations -- Under Construction	Orbita Stations -- Planned
Anadyr	Batagay
Bilibino	Tiksi
Nikolayevsk-na-Amure	
Okhotsk	Molniya-2 Stations -- Planned
Sovetskaya Gavan	
Tbilisi	Dudinka
Ust' Nera	Salekhard
Zeya	Zayarsk

a. Currently operational Soviet ground stations whose locations coincide with those of future Molniya-2 and/or Statsionar ground stations are identified by parenthetical designators.

the stations -- Alma Ata, Ashkhabad, Frunze, and Ulan Ude -- this switchover to color has been completed.

International

11. During the past year or so, the USSR has renewed and enlarged its commitment to provide satellite ground stations to other Communist countries, but there is no evidence of similar arrangements with any non-Communist country. Thus far, the only ground station actually built by the USSR outside its borders is an Orbita facility in the area of Ulan Bator, Mongolia. A period of more than two years elapsed between the agreement to build the station and the initial groundbreaking in April 1969, but once construction began the station was completed in only nine months.

12. A satellite ground station promised to Cuba almost five years ago has yet to materialize. In January 1970, however, this commitment was formalized into a written agreement which, for the first time, spelled out the fact that the Cuban station will have multiservice capabilities -- that is, it will be able to handle telephone and telegraph traffic in addition to television, and will be able to transmit as well as receive.

13. Firm evidence of Soviet intent to sponsor establishment of satellite ground stations in Eastern Europe has become available only in recent months. In March 1970 a Czech-Soviet communique announced that construction of an Orbita station would begin soon in Czechoslovakia. This was followed in July 1970 by an announcement indicating that the USSR was going to provide Bulgaria with a multiservice ground station. In neither case is there evidence that construction has been started yet nor have target dates for operational status been announced.

Program Costs

14. The figures presented below represent a rough approximation of the cost of the Soviet comsat program. In the absence of direct data on internal Soviet expenditures, the estimates were based on what it would cost (in US dollars) to duplicate the Soviet program in the United States. The methodology -- outlined in the Appendix -- makes substantial

use of costing models developed elsewhere, but these have been modified and amplified wherever necessary to make cost components conform as closely as possible to the unique parameters of the Soviet program.

15. Through mid-1970, total costs of the Soviet Molniya-1 program are estimated to have been somewhere between $700 million and $750 million. This estimate includes the cost of research and development, launchers, satellites, failures, ground stations, and yearly operating and maintenance costs.

16. The space segment of the Molniya program has been by far the most expensive element of the system because of the short operating lifetimes of the satellites. Each of the 14 Molniyas successfully orbited since 1965 probably has cost the USSR an estimated $33 million -- $20 million for the booster and $13 million for the satellite. The 14 Molniyas would cost about $460 million excluding the cost of failures. On the basis of a 75% probability of mission success the program probably has experienced about five failures (either booster or satellite), which would raise the total cost of the space segment alone to more than $600 million.

17. In comparison, ground station costs have been much lower. It is estimated that the approximately 30 Orbita stations cost between $1 million and $1.5 million each depending on the location and the hostility of the terrain. The two multiservice Molniya stations, larger and more complex than the Orbita stations, are estimated to have cost between $2.5 million and $3 million each. (A standard Intelsat ground station, by comparison, costs between $4 million and $6 million.) Total costs of Soviet ground station deployment probably have totaled somewhere between $40 million and $50 million.

18. Over the next two years or so, the development of Molniya-2 and Statsionar, continued expansion of the ground segment, and maintenance of the system probably will require outlays amounting to another $300 million to $350 million. It appears highly likely, therefore, that the total cost of the Soviet comsat program will exceed $1 billion by the end of 1972.

Trends in System Planning

Domestic

19. Soviet comsat system development continues to place primary emphasis on meeting domestic priorities and requirements. As a necessary adjunct to the new frequency plan for the Molniya-2 and Statsionar satellites, the Orbita stations are scheduled to be modified for operation in the 4 to 6 GHz range. In addition, Soviet planning calls for selected (but as yet undesignated) Orbita stations to be equipped for both transmission and reception of multichannel telephone and telegraph traffic. When fully operational, this network of multiservice ground stations will contribute substantially toward overcoming the serious lack of high capacity cable and microwave radio relay lines in the Soviet regions lying east of the Urals.

20. According to official Soviet information, the Molniya-2 and Statsionar satellites will work with a network of 21 cities in the USSR (see Table 1). Three of the cities -- Moscow, Novosibirsk, and Komsomolsk -- will have a ground station complement capable of operating with both Molniya-2 and Statsionar. Ground stations serving the remaining 18 cities are to be split evenly between the two systems. Since 18 of the 21 designated sites already have ground stations in operation, completion of the 21-city network will require the construction of only three new stations at Dudinka, Salekhard, and Zayarsk. The 18 existing ground stations will require technical modification in order to operate with the new satellites but this probably can be done with relatively moderate outlays of time and money. Soviet authorities have not indicated what is to be done with the Orbita stations that are not earmarked for operation with the new satellites. It seems likely that these unassigned stations also will operate with Molniya-2 or Statsionar but will be used only for reception of television.

International

21. Except for completion of the ground station in Mongolia and the formalizing of promises to build stations in Cuba, Czechoslovakia, and Bulgaria, little has occurred over the last year or so to clarify Soviet intentions in the international comsat field. Intersputnik, the Soviet-sponsored international comsat organization, has remained

essentially a "paper tiger": its membership has never increased beyond the original eight signatories -- all Communist countries -- and of late its existence is only infrequently mentioned, even by the USSR. Although seemingly moribund, Intersputnik may nevertheless be serving Soviet purposes. As signatories to Intersputnik, the other Communist countries are probably effectively restrained from seeking membership in Intelsat, the Western-based comsat consortium, and the USSR may also see in Intersputnik a bargaining counter that could prove useful in any future dealings with Intelsat.

22. In looking to the future, Soviet comsat authorities appear to have selected the frequency ranges for Molniya-2 and Statsionar with considerable shrewdness. The radio frequency bandwidth of the new Soviet satellites will overlap by 40% with frequencies used by Intelsat, thus opening up the possibility of technical cooperation between the two systems. However, with the remaining 60% of its bandwidth lying outside of the Intelsat frequency range, the USSR will be free to operate independently. The Soviet choice of frequency bands thus appears designed to give the USSR considerable technical flexibility in deciding how close or remote its future relationship with Intelsat will be.

Conclusions

23. The characteristics of the Soviet comsat program contrast sharply with those of the Western-based Intelsat consortium. The Soviet system has been developed primarily to satisfy domestic rather than international priorities and is used mainly for television distribution rather than for the relay of telephone and telegraph communications. Thus far, the Molniya/Orbita program has required outlays estimated at more than $700 million. Although expensive, the program has brought television to remote parts of the USSR at only a fraction of the cost of conventional cable and/or microwave radio relay lines.

24. Ultimately, the Soviet comsat system will be fully integrated into the terrestrial common carrier telecommunications network and will provide multichannel telephone, telegraph, and data services

in addition to television relay. The speed with which this is accomplished depends on the successful development and operational deployment of the new-generation Molniya-2 and Statsionar satellites. Substantial slippage in Soviet plans for these new satellites is suggested by the long string of failures encountered in tests of the booster to be used to launch Statsionar and also by the decision to orbit two more of the old Molniya-1s in 1970. It appears especially unlikely that the USSR will meet its December 1970 target date for placing the first Statsionar into equatorial synchronous orbit.

25. The USSR has shown little inclination thus far to establish the priorities and to commit the resources necessary to convert Intersputnik into an authentic rival of Intelsat. Soviet authorities may be reluctant to undertake major initiatives in this direction until their new-generation satellites have been successfully tested. Alternatively, Moscow might decide that cooperation with the 75-member Intelsat Consortium would be more advantageous to the USSR than attempting to compete by means of Intersputnik.

APPENDIX

Methodology for Costing the Soviet Comsat Program

Since the USSR has supplied virtually no information on the cost of its comsat program, an attempt has been made to estimate the cost of a comparable program in the United States. The basic reference material is from Chapters 12 and 13 of *Telecommunication Satellites* (Iliffe Books Ltd. and Prentice-Hall, 1964), edited by K. W. Gatland. This source was used for computing ground station costs and total system costs. Costs for the space segment of the Soviet comsat program were supplied by the Office of Strategic Research (OSR), CIA. Despite the use of many simplifying assumptions, the resulting estimate probably represents a reasonable approximation of the cost of the Soviet comsat program.

Ground Segment Costs

Orbita Ground Stations

Table 13.15 in Gatland was used to develop the basic component costs of an Orbita ground station. The table was modified to take into account the size of the Orbita antenna and the fact that Orbita stations do not have a transmission capability. The estimated cost components for an Orbita station are shown in Table 2.

Average cost of an Orbita station is estimated to range between $1 million and $1.5 million. The high side of the range reflects higher construction costs resulting from hostility of terrain and remoteness of site. The low side of the range reflects probable economies of scale as Orbita stations have moved toward the status of "off-the-shelf" production items.

Molniya Ground Stations

The cost of a Molniya ground station is also based on Table 13.15, modified to take into account the larger antenna size, number of antennas required, the transmission capability, power of the transmitter, and the multichannel communications capability (see Table 3).

Table 2

Initial Orbita Ground Station Costs

	Thousand US $
Equipment	
Antenna:	
Pedestal, reflector	232
Foundation	20
Data takeoffs	25
Servo circuitry	50
Transportation	23
Subtotal	350
Transmitters	0
Diplexers	0
Maser	50
Receiver, I.F. amplifier	5
Receiver, monopulse	50
Boresite equipment	50
Acquisition equipment	50
Teletype	0
Multiplex terminal equipment	0
Performance monitor	50
Computer	70
Standby power	9
Echo suppressors	30
Subtotal	714
Spares	107
Installation, engineering, and labor	200
Real estate improvements	250
Total	*1,271*

Table 3

Initial Molniya Ground Station Costs

		Thousand US $
Antenna:		
Pedestal, reflector	359	
Foundation	30	
Data takeoffs	25	
Servo circuitry	50	
Transportation	23	
Subtotal		486
Cost (two antennas)		972
Transmitters:		
Power amplifier	100	
Exciter	10	
Cost (two transmitters)	220	
Diplexers (two @ 20)		40
Masers (two @ 50)		100
Receivers, I.F. amplifiers (two @ 5)		10
Receivers, monopulse (two @ 50)		100
Boresite equipment		50
Acquisition equipment		50
Teletype		12
Multiplex terminal equipment		86
Performance monitor		50
Computer		70
Standby power		9
Echo suppressors		30
Subtotal		1,799
Spares, 15%		270
Installation, engineering, and labor		200
Real estate improvements		250
Total		*2,519*

A range of $2.5 to $3.0 million is used as the initial cost of a Molniya ground station.

Space Segment

The following cost figures have been supplied by OSR, based on known parameters of the Soviet Molniya-1 system and preliminary estimates for the follow-on systems.

a. Molniya-1:

Satellite cost .....$13 million each
Launch and booster costs.....$20 million each

b. Future costs

Molniya-2:

Satellite cost .....$22 million each
Launch and booster costs.$20 million each

Statsionar:

Satellite cost.....$22 million each
Launch and booster costs.$45 million each

c. Research and development costs.....$40 million

The space segment costs estimated for the USSR are much higher than comparable costs incurred by Intelsat owing primarily to the fact that the Soviet satellites are much larger. The estimated weight of Molniya-1 is 3,000 pounds. In contrast, the weights of the Intelsat satellites have been as follows:

Intelsat I ..... 85 pounds
Intelsat II.....190 pounds
Intelsat III.....322 pounds

The heavier Soviet payload is much more expensive in and of itself, as is the much larger booster required to place it into orbit.

Program Costs

Two different methods were used to compute the cost of the entire program to date. The first method is strictly additive -- merely a summing of all

estimated cash outlays. The second method uses a formula approach taken from Chapter 12 of Gatland. These methods are presented in Tables 4 and 5.

On the basis of the calculations in Tables 4 and 5, a range of $700 million to $750 million appears to be a reasonable approximation of total expenditures for the Soviet comsat program to date.

Future Expenditures

Although information on the future Molniya-2 and Statsionar programs is very fragmentary, an attempt was made to estimate future costs of the Soviet comsat program. Since the additional ground segment costs required to complete the program become insignificant in relation to the total cost of the program, they are not considered here.

The assumption is made that, by the end of 1972, the USSR will (a) launch one experimental Statsionar satellite and one for operational use and (b) that it will also test one Molniya-2, and then launch four additional Molniya-2s for optimum coverage of the USSR. On the basis of cost estimates supplied by CSR for launches and satellites, the additional expenditures required for Molniya-2 and Statsionar would be about $350 million. Adding this to the estimate of $700 million to $750 million for outlays already made brings the total estimated cost of the Soviet comsat program to over $1 billion by the end of 1972.

Table 4

Cost of Molniya-1 Comsat Program (Additive Method)

		Million US $
Research and Development		40
Space segment		
14 Molniya-1 satellites @ 13	182	
14 launches @ 20	280	
5 failures a/ @ 33	165	
Subtotal		627
Ground segment		
29 Orbita stations @ 1.25 average	36.25	
2 Molniya stations @ 2.75 average	5.50	
		42
Operational and maintenance costs		
1967-68 20 Orbitas @ .125	2.5	
1968-69 25 Orbitas @ .125	3.1	
1969-70 30 Orbitas @ .125	3.8	
1965-70 2 Molniya stations @ .275 x 5 years	2.7	
Subtotal		12
Total		721

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Table 5

Cost of Molniya-1 Comsat Program
(Formula Approach)

$C_T = C_D + C_E + C_O N$

Where C_T = total cost over N years incurred in the development, establishment and operation of a satellite communications system

C_D = R&D cost
C_E = initial establishment cost
C_O = operational and maintenance cost per year

also $C_E = n_g C_g + \frac{n_s}{p n_{sl}} (C_l + n_{sl} C_s)$

and $C_O = \frac{n_s}{p n_{sl} t} [C_l + C_b + n_{sl} C_s] + k n_g C_g$

where n_g = number of ground stations

n_s = number of satellites in operational system

n_{sl} = number of satellites per launch

p = probability of launch success

t = mean satellite life

k = annual cost of maintaining ground stations as proportion of establishment cost

C_g = cost of establishing ground station

C_s = cost of one satellite

C_l = total cost of launch excluding booster and satellite

C_b = cost of booster-rocket system

let C_D = 40

n_g = 11 for C_E and 25 as an average for C_O

n_s = 3

n_{sl} = 1

p = .75

t = 1.5

k = .10

Table 5

Cost of Molniya-1 Comsat Program
(Formula Approach)
(Continued)

C_g = 1.25 for Orbita and 2.75 for Molniya stations

C_s = 13

$C_1 + C_b$ = 20

N = 6 for satellites, 3 for ground stations

Substitution of the above values into the equation yields a C_T of 754 -- that is, a total estimated cost for the Soviet comsat program amounting to $754 million.